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AIR INTELLIGENCE INFORMATION REPORT

COUNTRY OR AREA REPORT CONCERNS
Czechoslovakia

[redacted]

SUBJECT (Descriptive title. [redacted]

THERMONUCLEAR ENGINES – for electric power and jet propulsion

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SUMMARY (Give summary which highlights the salient factors of narrative report. Begin narrative text on AF Form 112a unless report can be fully stated on AF Form 112. List inclosures, including number of copies)

1. Forwarded herewith is a translation of an article entitled "Thermonuclear Engines" (Thermonuklearni motory), by Engineer Oldrich Bunata, appearing in P: Kridla Vlasti (Wings of the Fatherland), No. 21, 15 October 1957, pp. 660-661.

2. The article briefly describes the basic thermonuclear reactions and examines the prospects of using thermonuclear reactors for electric power production and jet propulsion. The conclusion is reached that while the development of large-size thermonuclear reactors may be within the realm of possibility, the use of such reactors in aircraft and rockets "is beyond our present imagination". The application of energy released through the catalytic synthesis of gas nuclei by means of negative mu-mesons is considered a more [redacted]ising approach to this problem. [redacted]

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Fig. 1. Schematic Layout of Possible Thermonuclear Power Plant (for explanations, see text) (diagram).

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THERMONUCLEAR ENGINES

During the 10 years following World War II the world's attention centered on the development and use of the nuclear energy released by the fission of the nucleus of the uranium atom. It was considered at the time that a source of energy had been found that could satisfy the needs of mankind for a very long period to come. However, due to the comparatively limited supply of uranium (and, eventually, thorium) on our planet and the ever-increasing use of electric power, this source of energy will be exhausted within a few centuries. Furthermore, the release of atomic energy by this method entails considerable problems of decontamination of radioactive by-products created in the process of fission.

The splitting of the nucleus is not the only known method of atomic energy release. A far greater amount of energy is released during the fusion of the atoms of the lightest elements, especially hydrogen. This type of atomic reaction takes place in the sun and in other stars. On earth, such a reaction has so far been achieved only in the ominous hydrogen bomb.

The release of energy in the fission process of uranium nuclei occurs only in cases where the quantity of uranium is large enough to start a chain reaction. The reaction process is not primarily governed by temperature. For an instant, a multi-million degree temperature originates in the atomic bomb, while in an atomic reactor the temperature reaches only several hundred degrees C. It was assumed until recently that the fusion of hydrogen nuclei can be achieved only at multi-million degree temperatures. For this reason, such processes were called thermonuclear reactions. Before we try to explain the necessity for these high temperatures, let us show some of the reactions which are considered today of the foremost importance. In the course of these reactions, helium is created from various hydrogen isotopes:

$$H^2 + H^2 \rightarrow He^3 + n + 3.25 \text{ Mev}$$

$$H^2 + H^2 \rightarrow H^3 + p + 4.0 \text{ Mev}$$

$$H^3 + H^2 \rightarrow H^4 + n + 17.6 \text{ Mev}$$

$$He^3 + H^2 \rightarrow He^4 + p + 18.3 \text{ Mev}$$

H^2 is deuteron, often indicated as D, the nucleus of a well-known hydrogen isotope; compounded with oxygen it becomes heavy water with one proton and one neutron. H^3, also indicated as T (triton), is the nucleus of a further hydrogen isotope, tritium, which has one proton and two neutrons. He^3 and He^4 are nuclei of two helium isotopes with two protons and one or two neutrons. The remaining particles are neutrons (n) and protons (p).

In these equations the aggregate mass of the particles is slightly smaller than the aggregate mass of the original particles, and this difference, Δm, is changed into energy according to the Einstein formula $E = 1/2\ \Delta m \cdot c^2$, where c is the speed of light.

Although the speed of light is enormous, the energy released in one reaction is negligible because the mass of the particles changing into energy is infinitesimal. To obtain enough energy for efficient utilization, a great number of nuclear reactions must occur simultaneously. This same principle is applicable to the release of atomic energy through the splitting of an uranium atom. Energy released in nuclear reactions is measured in million electron volts (Mev). One Mev is the energy gained by an electron when it is acted upon by a potential difference of a million volts.

Mass particles, on entering the reactions described above, are positively charged and, therefore, repel each other. Yet, in order to produce the reaction, they should collide. This can be achieved by increasing the temperature of the particles many million degrees C; the particles then develop kinetic energy to the extent where repulsion forces are destroyed. In a hydrogen bomb this heat is attained through the chain reaction of splitting uranium nuclei, resulting in the thermonuclear reaction of changing hydrogen into helium. This process is, actually, one extremely violent explosion. Therefore, the use of thermonuclear reactions for the production of energy was, at first, viewed with considerable skepticism. However, the advantages to be gained by developing this source of energy are too great to be disregarded. Per unit of weight, about 1/3 more energy can be obtained from hydrogen than from uranium (the usable energy in deuterium is about $2 \cdot 2 \cdot 10^{10}$ kcal/kg). Deuterium can be obtained from sea water where the ratio of deuterium to normal hydrogen is about 1 : 7,000. However small this quantity may be, yet 60 times more energy can be obtained from 1 kg of water than from (1 kg of) coal. Compared with uranium, the supply of deuterium on earth is practically unlimited. The products of a thermonuclear reaction itself are not radioactive, which is another great advantage. Although, in the construction of a thermonuclear installation, the problem of shielding is still to be considered in view of a certain leakage of neutrons and protons during the reaction, it could, in all probability, be solved more readily than in a current-type (uranium) reactor.

For these reasons, scientists were not deterred by the obstacles encountered in the development of thermonuclear reactions as a source of energy, either for the production of electric power or for the propulsion of aircraft and rockets. Intensive work is being done on these problems, although, for obvious reasons, the results are not made known. Articles and basic mathematical analyses found in literature seem to indicate prevailing trends for the solution of this problem.

At present, a preliminary technical design has been made which specifies the dimensions of a chamber for thermonuclear reactions. These dimensions may decrease when pressure is introduced into the chamber, but even with a pressure of 100 atm, the chamber would still have to be 1,000 m in length and 100 m in diameter. The nuclei of gases in the center of the chamber would maintain a very high temperature which would decrease steeply toward the chamber walls. Because of the high temperature and pressure, the incandescent gases would have a very low density and would be almost transparent. Their radiation would equal that of a black body heated to a "mere" 4,000° C. The problem of cooling would present great, though not insurmountable difficulties. A schematic layout of a possible thermonuclear power plant is shown in Fig. 1 (see inclosure). At the end of a chamber (1) gases are deuterium-cooled to a temperature permissible for a gas turbine (2) which would drive a compressor (3) and an electric generator (4). Upon leaving the turbine gases enter a separator (5) where fusion products H^3 and He^4 are segregated. From the separator deuterium is passed through a cooler (6), more deuterium is added, and the gases are directed back into the compressor,(3). There, the deuterium is once more compressed to 100 atm and passed to the chamber (1). In spite of the exceedingly high temperatures of the gas nuclei, the amount of heat in the chamber (per 1 cu m of volume) would be about 10 times less than in combustion chambers of jet engines.

A thermonuclear reaction can be started by achieving fission of uranium. It seems quite possible, however, that other ways of starting a thermonuclear reaction will be discovered. E.g., such reactions have been spotted in a pulsating electric arc of high intensity.

Although the active heat zone in the chamber would be comparatively small, the minimum capacity of the installation would have to be very large. In fact, a power plant operated on thermonuclear fuel would produce about 5 times more electric energy than the entire 1954 power output in the USA.

The construction of a stationary reactor of such large dimensions with incandescent walls and an inner pressure of 100 atm presents serious problems. The use of this type of installation for jets is beyond our present imagination. Even if the dimensions of the chamber were to be considerably reduced, the possibility of using them for driving airplanes or rockets seems too remote for consideration. Yet, the latest discoveries in this field show a way to overcome seemingly insurmountable obstacles. It has been ascertained that the transition of hydrogen into helium is not necessarily dependent upon high temperatures. Under certain conditions a negative mu-meson can produce the fusion of deuterium and hydrogen nuclei, releasing an energy equivalent of 5.4 Mev. This phenomenon is called catalytic synthesis of nuclei and does not require a preliminary increase in temperature. The life of negative mu-mesons being very short, it is impossible at present to use this event for obtaining energy, but experiments in this direction will, no doubt, continue. In this type of nuclear engine temperatures would be considerably lower, the dimensions would be much smaller, while the output achieved would be quite large. Thus, the design of a new motor of the future is beginning to take shape, promising great advantages over the atomic engine powered by uranium fission.

The XX-th century reveals possibilities heretofore unknown to humanity. The responsibility for using this knowledge for future prosperity and development instead of for annihilating wars lies with the entire mankind.

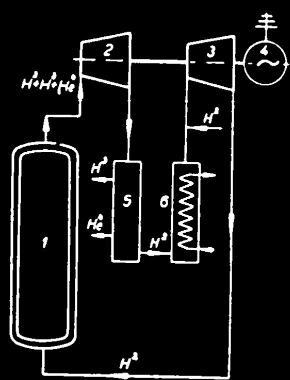

Fig. 1. Schematic Layout of Possible Thermonuclear Power Plant (for explanations, see text)

Source: P: Kridla Vlasti, No. 21, 15 October 1957, p. 660

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